# USING LANDSAT IMAGES TO OBSERVE COASTLINE CHANGES IN MEKONG RIVER DELTA, VIETNAM

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**ABSTRACT:** Mekong River Delta, is located at the southern of Vietnam, covers a large area that is approximately 40,000 square kilometers. Its surrounding coastline comprises of the east part and the west part. The east coastline lengthens from Ho Chi Minh City to Ca Mau headland (South China Sea), while the west coastline distributes from Ca Mau headland to Ha Tien town (Thailand Gulf). Most of areas are low plains with mean altitude ranged from less than 0.5 meter to approximately 10 meters. These areas are sensitive with the rising of the global mean sea level in present and future times. To gain a better understanding of this vulnerable area and make a good plan for the future, it is crucial to observe and calculate the erosional and depositional areas, as well as to study the coastline changes from past to present time. In this research, we use multi-temporal Landsat imagery acquired from 1972 to 2005 to detect the coastline from each image. Comparing the derived coastlines enables us to observe and calculate the areas of erosion and deposition in each stage. Landsat imagery with 30 meters resolution is provided free by NASA that is appropriated for observing in a large area such as Mekong River Delta. The result is useful for studying the changing rates and the factors of the erosion and deposition in Mekong river delta. This research also provides the useful information for land-use planning, as well as warning and finding out methods to overcome the consequence of rising sea level in future.

## 1. INTRODUCTION

Mekong River Delta, is located at the southern of Vietnam, covers a large area that is approximately 40,000 square kilometers. Its surrounding coastline comprises of the east part and the west part. The east coastline lengthens from Ho Chi Minh City to Ca Mau headland (South China Sea), while the west coastline distributes from Ca Mau headland to Ha Tien town (Thailand Gulf). This area is also the largest plain of Vietnam and supplies mainly rice for exporting. Most of areas are low plains with mean altitude ranged from less than 0.5 meter to approximately 10 meters. These areas are sensitive with the rising of the global mean sea level in present and future times. Study area is located mainly in deltaic plain that covers five provinces of Cuu Long river plain (Mekong River Delta) in

Vietnam, includes My Tho, Ben Tre, Tra Vinh, Soc Trang, and a part of Bac Lieu, the coastline lengthens approximate 226 kilometers (*figure 1*).

The development of Remote Sensing (RS) and Geographical Information systems (GIS) technology can supports mapping and detecting useful information that always updated on time. Beside some types of satellite imagery with medium resolution, such as Landsat images that downloaded freely from website of NASA (*http://www.glcf.umd.edu/data/*) appropriate with the research of erosion or deposition in large area like Mekong River Delta. To gain a better understanding of this vulnerable area and make a good plan for the future, it is crucial to observe and calculate the erosional and depositional areas, as well as to study the coastline changes from past to present time.

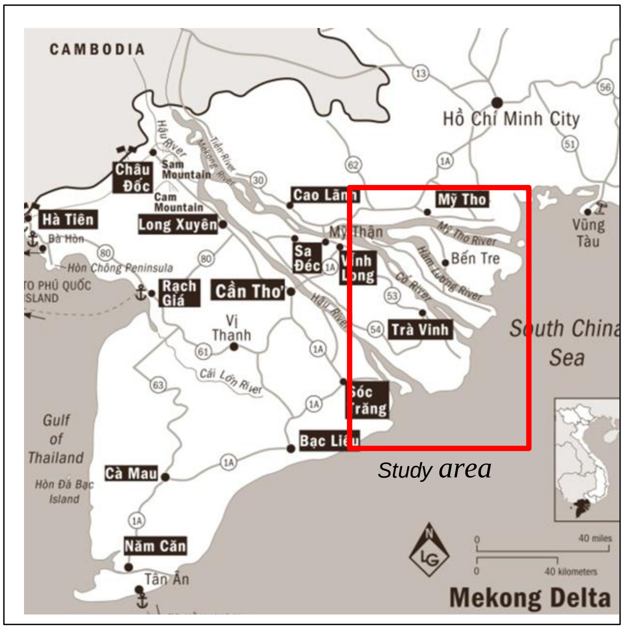


Figure 1: Map of study area

## 2. DATABASE AND METHODOLOGY

In this research, we used Landsat images in many periods from 1972 to 2005 (table 1) to detect coastlines and compare together. After that, depending on these coastlines to detect and calculate erosional and depositional areas.

### 2.1. Database

Landsat images that are used to study include in Landsat MSS in 1972 (4 bands), Landsat TM in 1989 (7 bands), Landsat ETM+ in 2001 (8 bands) and Landsat ETM+ 2005 (8 bands) (*table1*).

Periods of detecting satellite images always correspond with low tides. Tidal data of periods that are considered and collected from website of Sai Gon Harbor (*http://www.csg.com.vn/code/e_tidalchart.jsp*) and The South Regional Hydrometeorological Center show tidal fluctuations of periods are always less than 0.5 meter. This is not affected to changing area by tide significantly. Then changing of coastlines of periods that affected by tide was ignored.

ENVI 4.5 software is used to choose and create composite images, and ARCGIS 9.3 software is used detect coastline of each year and calculate erosional and depositional areas.

Table 1: Information of sensors and used bands

| ***Sensor*** | ***MSS*** | | ***TM*** | | ***ETM+*** | | |
|---|---|---|---|---|---|---|---|
| ***Band*** | ***Wavelength*** | ***Used bands*** | ***Wavelength*** | ***Used bands*** | ***Wavelength*** | ***Used bands*** | ***Used bands*** |
| ***1*** | | | *0.45-0.52 µm* | *x* | *0.45-0.52 µm* | *x* | *x* |
| ***2*** | *0.5-0.6 µm* | *x* | *0.52-0.6 µm* | | *0.53-0.61 µm* | | |
| ***3*** | *0.6-0.7 µm* | | *0.63-0.69 µm* | | *0.63-0.69 µm* | | |
| ***4*** | *0.7-0.8 µm* | *x* | *0.76-0.9 µm* | *x* | *0.75-0.9 µm* | *x* | *x* |
| ***5*** | *0.8-1.1 µm* | *x* | *1.55-1.75 µm* | *x* | *1.55-1.75 µm* | *x* | *x* |
| ***6*** | | | *10.4-12.5 µm* | | *10.4-12.5 µm* | | |
| ***7*** | | | *2.08-2.35 µm* | | *2.1-2.35 µm* | | |
| ***8*** | | | | | *0.52-0.9 µm* | | |
| ***Date*** | *1972.12.15* | | *1989.01.16* | | *2001.12.11* | | *2005.01.20* |
| ***Spatial resolution*** | *80m* | | *30m* | | *30m*<br>Band 8: 15m | | |

### 2.2. Methodology

Optimum Index Factor (OIF) (*Chavez, 1982*) method is used to choose a set of three bands to create a best composite image (*equation 1*) that can observe clearly the boundaries of land and sea. The information about wavelength and used bands is presented in table 1.

Equation 1: Optimum index factor equation

$$OIF = \frac{\sum_{k=1}^{3} S_k}{\sum_{1}^{3} Abs(r_{kl})}$$

$S_k$: standard deviation

$r_{kl}$: Correlation

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Detecting the coastlines of each year depends on composite images that create from ENVI 4.5 software. Corresponding with each composite image, the coastlines are detected (in 1972 - *figure 2*; in 1989 - *figure 3*; in 2001 - *figure 4*; in 2005 – *figure 5*). ARCGIS is used to overlap the coastlines of four periods and to find out the positions of erosional and depositional areas (*figure 6, 7, 8 and 9*). Total of erosional areas and total of depositional areas in three stages (1972 - 1989), (1989 - 2001) and (2001 - 2005) are calculated (*table 2*).

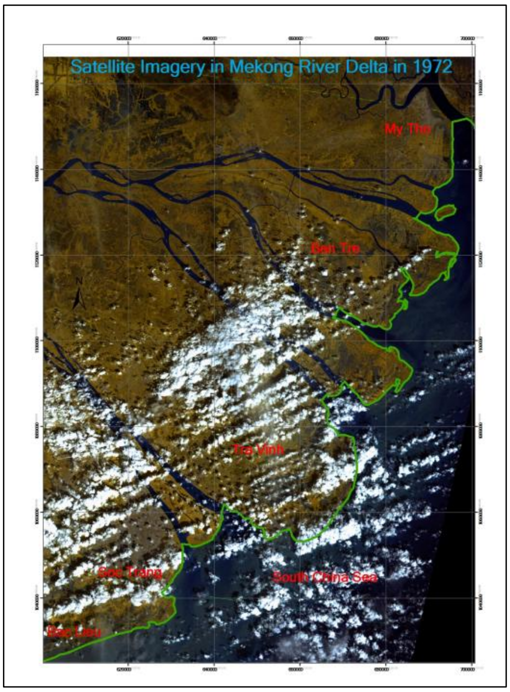


*Figure 2*: coastline 1972

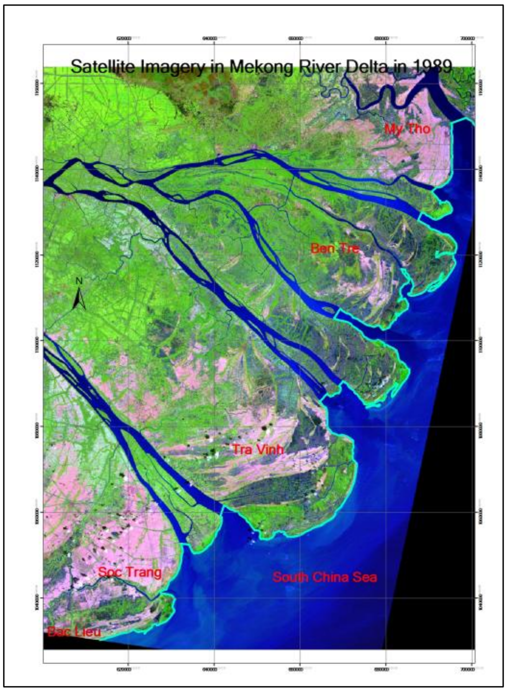


*Figure 3*: coastline 1989

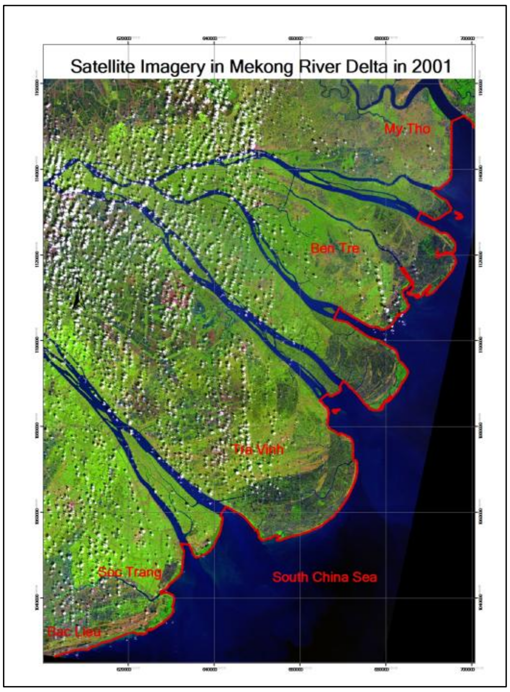


*Figure 4*: Coastline 2001

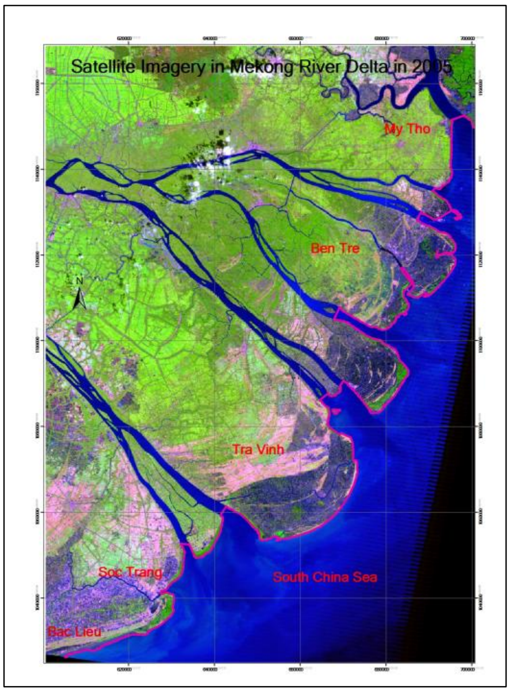


*Figure 5*: Coastline 2005

## 3. RESULTS

Distributions of erosional areas and depositional areas (*figure 7, 8, and 9*), and results (from table 2) show that the erosion in there is more dominant than the deposition. The erosional direction trends to the north-east whereas the depositional direction trends to the south-west (*figure 7, 8 and 9*).

Erosional rate of each year decreases gradually from 1972 to 2005 while tendency of depositional rate increases gradually (*table 2*).

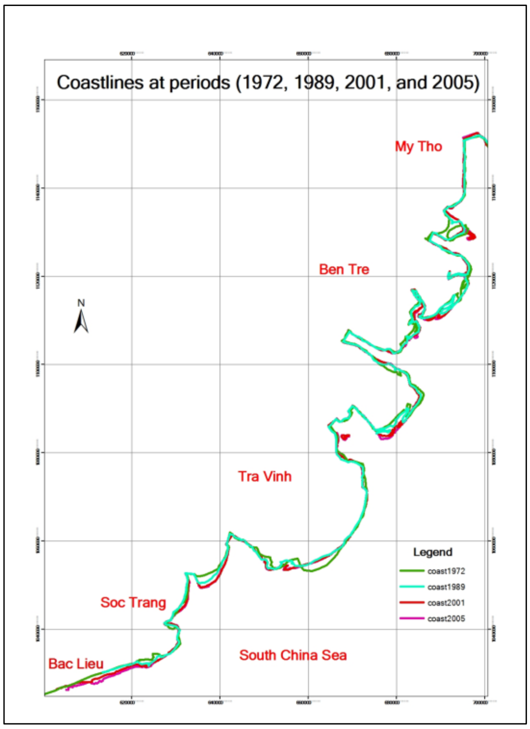


Figure 6: Coastlines of four periods

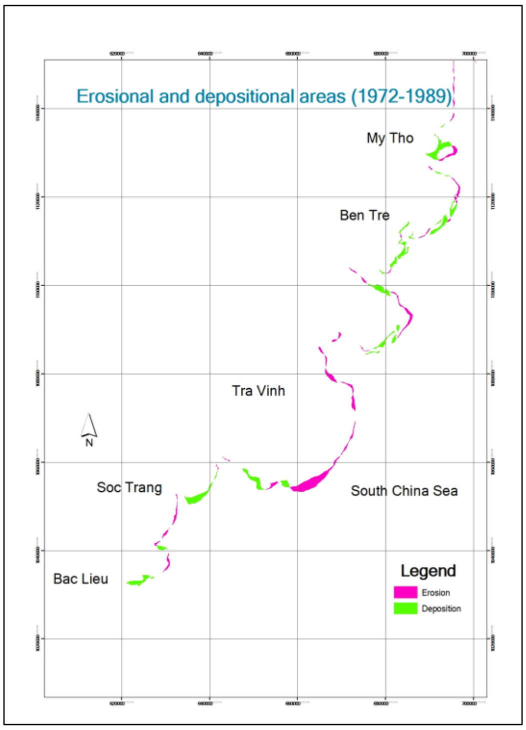


Figure 7: Erosion and deposition in 1972-1989

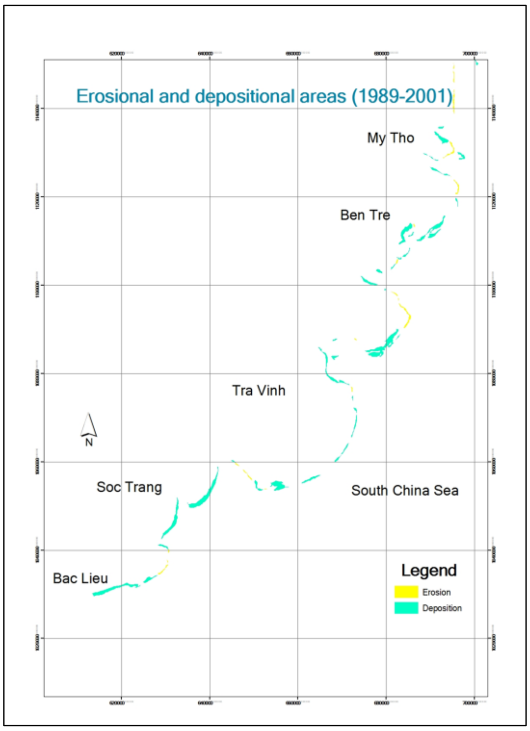


Figure 8: Erosion and deposition in 1989-2001

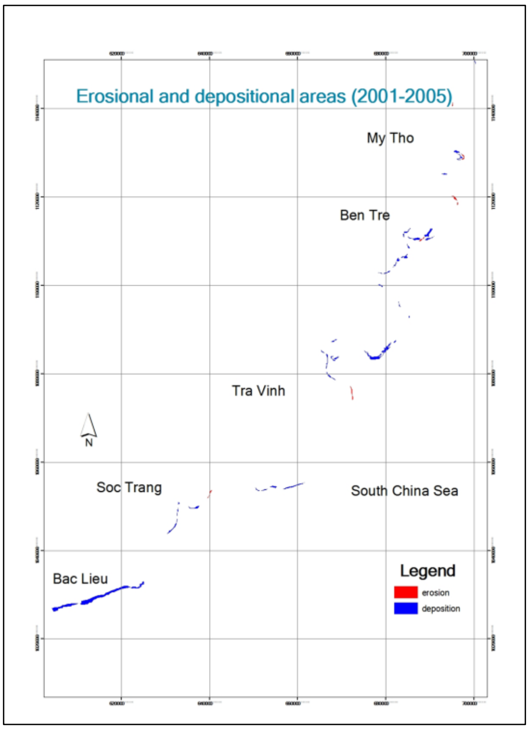


Figure 9: Erosion and deposition in 2001-2005

Table 2: Statistics of erosion and deposition in study area

| *Range of time* | *Number of years* | *Total of erosion* | *Total of deposition* | *Erosional rate of each year* | *Depositional rate of each year* |
|---|---|---|---|---|---|
| 1972-1989 | 17 | 47.897259 | 52.775891 | 2.817485824 | 3.104464176 |
| 1989-2001 | 12 | 7.502235 | 66.125172 | 0.62518625 | 5.510431 |
| 2001-2005 | 4 | 1.70214 | 25.530358 | 0.425535 | 6.3825895 |

## 4. DISCUSSION AND CONCLUSION

Comparing the derived coastlines enables us to observe and calculate the areas of erosion and deposition in each stage. Landsat imagery with 30 meters resolution is provided free by NASA that is appropriated for observing in a large area such as Mekong River Delta. The result is useful for studying the changing rates and the factors of the erosion and deposition in Mekong river delta. This research also provides the useful information for land-use planning, as well as warning and finding out methods to overcome the consequence of rising sea level in future. However, non-continuous data of Landsat satellite images by cloud coverage that makes results are not objective and balance when dividing range of time (three different ranges of time with their differential is too large (four years of range from 2001 to 2005 and 17 years of range from 1972 to 1989)). This method can be applied more effectively and accurately with different images that recorded continuously.

## REFERENCES


http://www.csg.com.vn/code/e_tidalchart.jsp

http://landsat.gsfc.nasa.gov/

Alesheikh, A.A., Ghorbanali, A., Nouri, N., (2007). *Coastline change detection using remote sensing*. Int. J. Environ. Sci. Tech., 4 (1), pp. 61-66.

Chavez et al (1982) – Le Van Trung (2005). "*Vien Tham*" (Chuong 10). National University Ho Chi Minh city Publishing House, page 243.

Coleman J. M. (1982). Processes of Deposition and Models for Exploration. *International Human Resources Development Corporation*, Boston, 124p.

Elizabeth H. Boak and Ian L. Turner (2005). Shoreline Definition and Detection: A Review. *Journal of Coastal Research*, 21(4), pp. 688-703.

Ngo Thi Phuong Uyen, Nguyen Van Lap, Ta Thi Kim Oanh (2007), Coastline change in Ben Tre province, Mekong River Delta. *Platform International Conference on Natural Disaster Mitigation in the Coastal Regions of Tropical Asia – Mangrove: Important Issue for the Coastal Environment*, pp.27